PEAK Urban

Towards more equitable and sustainable urban water systems in India: The role of granular data

Author: **Krishnachandran Balakrishnan**

Indian Institute for Human Settlements

To achieve more equitable and sustainable water systems, granular data that helps to understand neighbourhood-level conditions and make spatially disaggregated assessments of urban water balance is needed. Urban water policy, as well as data collection and dissemination, are critical in this regard. This briefing provides key recommendations for this based on insights from research conducted in Bengaluru, India.

Key results

1. Using the case of Bengaluru, we demonstrate the extent of intra-urban inequalities in the availability of domestic piped water.
2. Current reporting frameworks that use citywide averages need to be modified to move towards a better understanding of intra-urban inequality.
3. Water deficits experienced by households are met through some form of groundwater usage. Using data from Bengaluru, we also show the extent of groundwater dependence, the sources of recharge and their relative importance in a spatially disaggregated format.
4. Existing groundwater monitoring systems are highly inadequate to understand the water balance in urban settings. Our work demonstrates the need for an urban groundwater monitoring program throughout India.

Indian city's water use is dependent on groundwater (Narain, 2012)

What hangs in the balance?

Access to adequate piped water is a necessity for households in urban areas. Progress towards SDG 11, SDG 6 and SDG 3 is dependent on our ability to make urban water systems more equitable, resilient, and sustainable (United Nations, 2017). But India's current water utility service level reporting frameworks—framed in 2008—focus on citywide averages, which can obscure intra-urban variations. While the reporting framework acknowledges this limitation, the lack of emphasis on need for intra-urban scale reporting has meant that, after more than a decade, India still does not have reliable information on actual conditions of households and neighbourhoods when it comes to this key service (MOUD, 2008).

Intra-urban inequality in access to domestic piped water supply is closely connected to groundwater dependence since the deficit in urban piped water supply is mostly met through alternative modes of supply, which rely on some form of groundwater. Existing literature, including our research, demonstrates that at least half of an Indian city's water use is dependent on groundwater (Narain, 2012). In addition, groundwater can be a crucial buffer when the water utility is faced with inadequate surface water availability. Thus, groundwater is a critical part of the overall urban water supply. But we have very little understanding of urban groundwater since our existing monitoring systems are inadequate at capturing its highly heterogeneous nature (Sekhar et al. 2018).

Drawing on insights from our research in Bengaluru, we provide policy recommendations to improve our understanding and action on intra-urban inequalities in piped water access and urban water balance in Indian cities. Without a more granular understanding of these aspects, we cannot make Indian cities equitable, resilient, or sustainable, when it comes to urban water systems.

Key findings:

1. In terms of citywide average water supply, measured in litres per person per day (lpcd), Bengaluru meets India's water supply service level benchmark of 135 lpcd. But our research shows that there is severe intra-urban inequality in domestic piped water availability in Bengaluru and that this is closely related to caste/class/religious composition of neighbourhoods.

The Service Level Benchmark for urban water supply in India is 135 lpcd (MOUD, 2008). But this is a citywide average benchmark. Analysis of intra-urban variation in domestic piped water availability is difficult since water supply data from water utilities and population data from the Census of India typically use different spatial units which do not necessarily align well with each other. For instance, in Bengaluru, water supply data from the Bangalore Water Supply and Sewerage Board (BWSSB) is available for spatial units called service stations, but as **Figure 1** shows, the boundaries of these do not align well with Bengaluru's wards - which are the administrative units for which census data is typically available .

As part of the PEAK Urban research project, we developed a method to generate 30m x 30m resolution population maps using ward-level census data in conjunction with other ancillary spatial datasets (Balakrishnan, 2016; Raveendran et al., 2022). We then used the data disaggregated at 30m x 30m to compute population residing in each of the service stations of Bengaluru. This enables us to understand domestic piped water availability within each service station boundary —at least for the people who are counted as residents in the census. We restricted our analysis to the central areas of Bengaluru which were part of its municipal corporation prior to its 2007 expansion since these areas have the best connectivity to the piped water network, based on the 2011 census (Balakrishnan, 2016).

Our results show that there is very high variation of domestic water supply even within the central area that has high levels of network connectivity (**Figure. 2**). Moreover, we find that some of the largest patches, which receive very low levels of water supply, are areas with very low socio-economic indicators and very high levels of Scheduled Caste population, as evident from the 2011 Census data. Comparison with spatial data on religion generated from electoral rolls by Susewind (2016) indicates that many of the areas with greater concentration of minority religion population tend to have lower levels of water supply. Our findings are further corroborated by other recent research on intra-urban piped water inequality in India (Saroj et al., 2020).

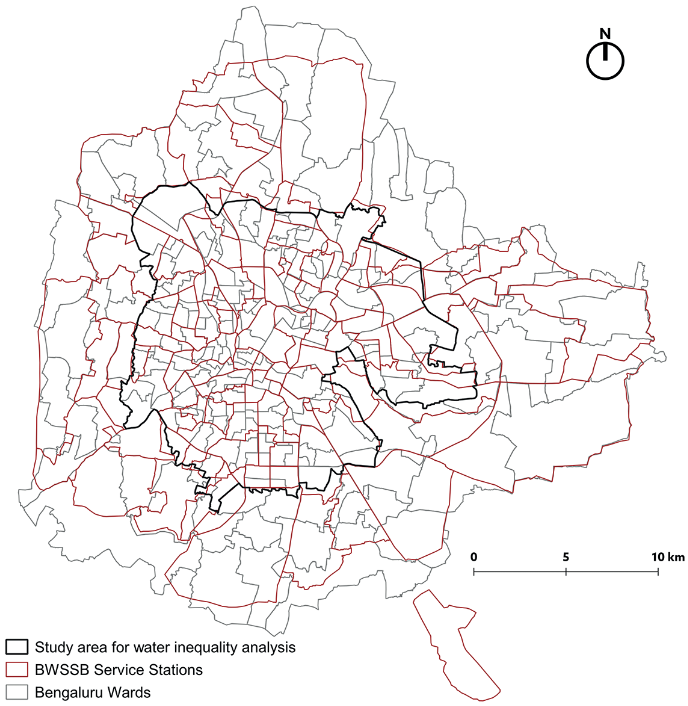


Figure 1. Bengaluru wards (grey) with water utility service stations (red) and boundary of study area for water inequality analysis (black)

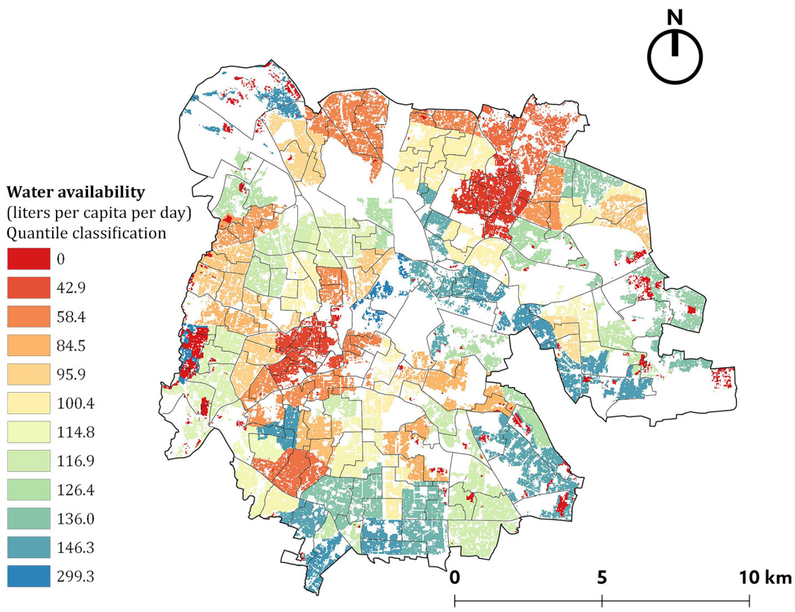


Figure 2. Domestic piped water availability in litres per capita per day (lpcd) for the study area shown in Fig. 1, overlaid with ward boundaries in grey.

2. Current groundwater monitoring for Indian cities is of very low resolution, both spatially and temporally. Bengaluru Urban District, with an area of more than 2000 sq.km., has only 20 monitoring bore wells, which are monitored only four times a year (CGWB, 2019). In comparison, using monthly groundwater level data from 155 bore wells for a 700 sq.km. area that covers most of Bengaluru city, we have been able to estimate spatially disaggregated urban water / groundwater balance and intra-urban variation in groundwater extraction, as well as identify the relative importance of various sources of recharge.

For urban water resilience and sustainability, it is imperative that we have a spatially disaggregated understanding of the urban water balance – the water that enters and exits the system. But we do not have this understanding for any Indian city for the following reasons:

i. A large component of the urban water balance consists of groundwater-based sources which are used to make up for the deficit in piped water supply. This involves both extraction from within the city and groundwater imports from outside the urban boundary to meet domestic, commercial, and other industrial requirements.

ii. Existing groundwater monitoring in India is too coarse in both spatial and temporal resolution to give us an adequate understanding of groundwater extraction – both within the city and from areas outside the urban boundary.

As part of the PEAK Urban project, we addressed the above problem for Bengaluru. We collaborated with researchers from multiple other institutions to estimate overall urban water balance for Bengaluru, using monthly groundwater level data from 155 borewells across a 700 sq.km. area covering most of the city.

Our results show that, as of 2016, average daily water use in Bengaluru was about 1470 million litres a day (MLD), of which more than 56% was dependent on groundwater extraction of some kind (**Figure 3**). Of the total groundwater recharge happening in and around Bengaluru, more than 80% can be attributed to non-rainfall sources like leaking water supply lines, sewer lines and septic tanks. In terms of citywide totals, the recharge from these anthropogenic sources is nearly 95% of the total groundwater extraction (Tomer et al., 2020).

Our spatially disaggregated analysis shows that there is considerable variation in groundwater extraction, recharge, and water levels across the city. The central parts of the city, which, in general, have better piped network coverage, has relatively low per capita groundwater extraction and high groundwater levels, while the newly urbanised peripheral areas have high per capita groundwater extraction and low groundwater levels. These findings corroborate broader patterns identified by other researchers (eg: Foster, 1998).

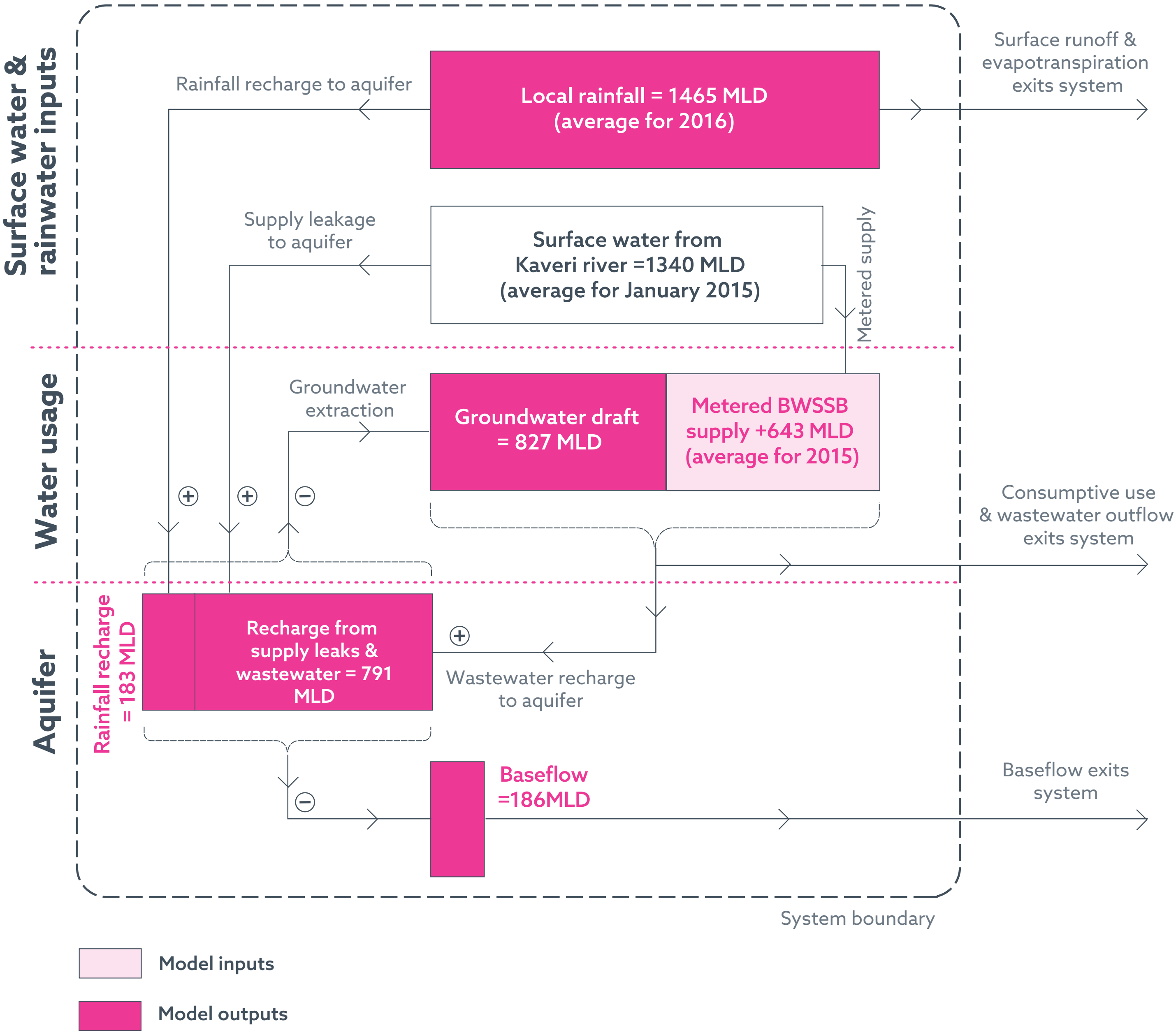


Figure 3. Average daily water balance estimates for Bengaluru city in million litres a day (MLD). The boxes are proportionate to volume of water.

Policy Findings:

1. Our findings about inequality in the availability of domestic piped water within Bengaluru demonstrate the need for policies and service-level benchmarks to urgently address uneven intra-urban water availability. Without such a focus, there is a serious disconnect between the intentions of lpcd-based benchmarks and our ability to understand per capita water availability for households, since citywide averages mask variation.

2. To ensure water utilities account for and address intra-urban variability in service delivery, three interventions are required:

i. Water utilities typically do not have data on the population residing within their smaller spatial units of service; instead, they only have data on the number of connections within these spatial units. Water utilities must be mandated to work with both population and connection data, since the focus should be on service provision rather than just infrastructure connectivity.

ii. As we have discussed, computing population within spatial units used by water utilities is very difficult since ward-level population data from the census is too coarse and does not align with water utility spatial units. To overcome this, Census Enumeration Block (CEB) boundaries must be publicly released for Indian cities such that the publicly available CEB level tabular data of total and SC/ST population can be mapped and aggregated to water utility spatial units. Notably, the Handbook on Service Level Benchmarks, an aid to implement systems for measuring, reporting, and monitoring Service Level Benchmarks, mentions the need to account for floating residential population of tourists and other such groups. But before we can get to that, at least the residential population as per census should be computed accurately.

iii. There should be a maximum threshold for the smallest spatial units in which water utilities collect supply and/or billing data. This should be decided based on the total population within these units as computed using the mapped CEB data. The water accounts for these smallest spatial units should be released publicly.

3. Our findings about urban groundwater / water balance in Bengaluru demonstrate the urgent need for an urban groundwater monitoring program in India with sufficient spatial and temporal resolution. Current groundwater monitoring systems are too coarse to deal with the heterogeneity within cities. The data collected through this urban groundwater monitoring program should be made publicly available.

4. Incentivizing the development of low-cost telemetry-based groundwater monitoring devices can help make this monitoring program financially feasible.

5. Through these interventions, Indian cities need to move towards a more granular analysis of variability in intra-urban water availability and spatially disaggregated water balance accounting, which takes into account not only the water within the infrastructure system, but also, the stocks and flows in the ground and surface water systems.

Further reading

Balakrishnan, K. (2022). Inequality in access to domestic piped water supply in Bengaluru. Manuscript submitted for publication.

Balakrishnan, K. (2020). A method for urban population density prediction at 30m resolution. Cartography and Geographic Information Science, 47(3), 193-213.

Balakrishnan, K., & Anand, S. (2015). Sub-cities of Bengaluru: Urban heterogeneity through empirical typologies. *Economic and Political Weekly*, 63-72.

Raveendran, S., Balakrishnan, K., Tripathy, P., Krishna Kumar, P., (2022)., A Bayesian modelling framework for uban population density prediction at 30m resolution. Manuscript in preparation.

S. K. Tomer , M. Sekhar , K. Balakrishnan , Deepak Malghan , S. Thiyaku , M. Gautam & Vishal K. Mehta (2020): A model-based estimate of the groundwater budget and associated uncertainties in Bengaluru, India, Urban Water Journal. https://doi.org/10.1080/1573062X.2020.18362377

References

Balakrishnan, K. (2016). Heterogeneity within indian cities: Methods for empirical analysis doi:**http://escholarship.org/uc/item/8sr333g9**;

Central Ground Water Board (CGWB). (2019). *Ground water year book of Karnataka (2018-19)*

Foster, S. (1998). *Groundwater in urban development: Assessing management needs and formulating policy strategies*. (World Bank Technical Report No. 390). Washington D.C.: The World Bank.

Ministry of Urban Development (MOUD). (2008). *Handbook of service level benchmarking*. New Delhi: Ministry of Urban Development, Government of India.

Narain, S. (2012). Excreta matters. (State of India's Environment: A citizens report No. 7 (Vol.1)). New Delhi: Center for Science and Environment.

Saroj, S. K., Goli, S., Rana, M. J., & Choudhary, B. K. (2020). Availability, accessibility, and inequalities of water, sanitation, and hygiene (WASH) services in indian metro cities. *Sustainable Cities and Society*, 54, 101878.

Sekhar, M., Tomer, S. K., Thiyaku, S., Giriraj, P., Murthy, S., & Mehta, V. K. (2018). Groundwater level dynamics in Bengaluru city, India. Sustainability, 10(1), 26.

Suswind, R. (2016). Data on religion and politics in India. https://github.com/raphael-susewind/india-religion-politics;

S. K. Tomer , M. Sekhar , K. Balakrishnan , Deepak Malghan , S. Thiyaku , M. Gautam & Vishal K. Mehta (2020): A model-based estimate of the groundwater budget and associated uncertainties in Bengaluru, India, Urban Water Journal. https://doi.org/10.1080/1573062X.2020.18362377

United Nations. (2017). *Work of the statistical commission pertaining to the 2030 agenda for sustainable development*

This brief was authored by Krishnachandran Balakrishnan and Francisco Obando was the managing editor. It draws on key findings from the journal articles:

Balakrishnan, K. (2022). *Inequality in access to domestic piped water supply in Bengaluru*. Manuscript submitted for publication.

Balakrishnan, K. (2020). A method for urban population density prediction at 30m resolution. Cartography and Geographic Information Science, 47(3), 193-213.

Balakrishnan, K., & Anand, S. (2015). Sub-cities of Bengaluru: Urban heterogeneity through empirical typologies. *Economic and Political Weekly*, 63-72.

Raveendran, S., Balakrishnan, K., Tripathy, P., Krishna Kumar, P., (2022)., A Bayesian modelling framework for uban population density prediction at 30m resolution. Manuscript in preparation.

S. K. Tomer , M. Sekhar , K. Balakrishnan , Deepak Malghan , S. Thiyaku , M. Gautam & Vishal K. Mehta (2020): A model-based estimate of the groundwater budget and associated uncertainties in Bengaluru, India, Urban Water Journal. **https://doi.org/10.1080/1573062X.2020.18362377**

About us

The PEAK Urban programme aims to aid decision-making on urban futures by:

1. Generating new research grounded in the logic of urban complexity;

2. Fostering the next generation of leaders that draw on different perspectives and backgrounds to address the greatest urban challenges of the 21st century;

3. Growing the capacity of cities to understand and plan their own futures.

In PEAK Urban, cities are recognised as complex, evolving systems that are characterised by their propensity for innovation and change. Big data and mathematical models will be combined with insights from the social sciences and humanities to analyse three key arenas of metropolitan intervention: city morphologies (built forms and infrastructures) and resilience; city flux (mobility and dynamics) and technological change; as well as health and wellbeing.

Contact

Krishnachandran Balakrishnan
kbalakrishnan@iihs.co.in

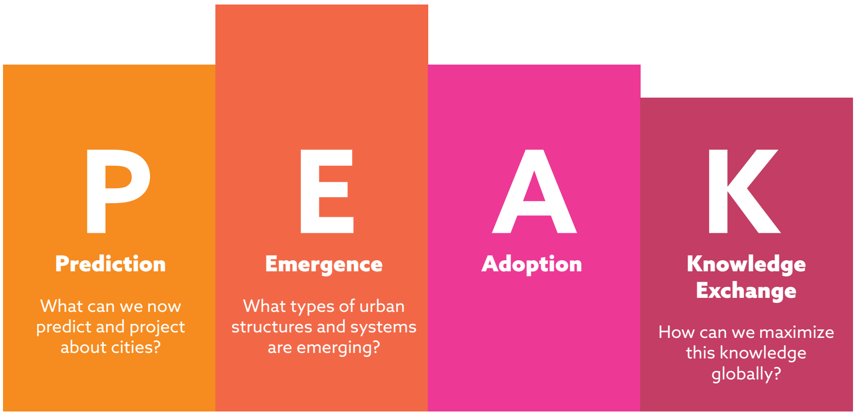
Published by PEAK Urban: June 2022

PEAK Urban is managed by the Centre on Migration, Policy and Society (COMPAS)

School of Anthropology and Museum Ethnography,
University of Oxford,
8 Banbury Road,
Oxford, OX2 6QS

+44 (0) 1865 274706
@PEAK_Urban
www.peak-urban.org

Our framework



The PEAK Urban programme uses a framework with four inter-related components to guide its work.

First, the sciences of **Prediction** are employed to understand how cities evolve using data from often unconventional sources.

Second, **Emergence** captures the essence of the outcome from the confluence of dynamics, peoples, interests and tools that characterise cities, which lead to change.

Third, **Adoption** signals to the choices made by states, citizens and companies, given the specificities of their places, their resources and the interplay of urban dynamics, resulting in changing local power and influencing dynamics.

Finally, the **Knowledge** component accounts for the way in which knowledge is exchanged or shared and how it shapes the future of the city.

PEAK Urban is funded by UK Research and Innovation as part of the Global Challenges Research Fund.

PEAK Urban is a partnership between: